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NAS9-150

February 1, 1965

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Report Period
December 16, 1964, to January 15, 1965

[redacted] ~~TO NASA HEADQUARTERS~~ [redacted]

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SPACE and INFORMATION SYSTEMS DIVISION

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DESCRIPTIVE TERMS

Contractually required monthly report

ABSTRACT

Brief illustrated narrative report of Apollo program progress for the report period, highlighting accomplishments, milestone achievements, and a continuing summary of the program.

PROGRAM MANAGEMENT

STATUS SUMMARY

The spacecraft 001 service module was delivered to the White Sands Missile Range (WSMR) for propulsion engine development testing. The module arrived at WSMR on December 18.

A design engineering inspection for boilerplate 22 was conducted by NASA and S&ID on December 18. The close-out operations on the aft heat shield of the boilerplate 22 command module were completed on December 29, and the boost protective cover was fit-checked with the launch escape tower on December 31. Stacking and alignment operations of the command and service modules of the boilerplate were completed in building 290 on January 15.

Acceptance checkout, facility, and ground support operations required to support the sequencer tests of boilerplate 14 (house spacecraft 1) continued during the report period.

Revision 2 to the Apollo master development schedule was distributed during the report period. The revision covers Block I and Block II Apollo spacecraft. Copies of the revision were distributed to functional S&ID departments and NASA on December 28.

SUBCONTRACTOR SUPPORT

Final evaluation of the Lockheed Aircraft successful qualification tests of the launch escape and pitch control motors occurred during the period. Lockheed is the first major subcontractor to complete qualification tests and obtain approval.

Group 1 qualification testing on 16 components of the environmental control subsystem has been completed by AiResearch.

DEVELOPMENT

SYSTEM DYNAMICS

Aerodynamics

Boilerplate 23 postflight analysis was continued; the results confirmed the preliminary evaluation reported last month. All test objectives were successfully achieved including separation of the launch escape vehicle from the command module, launch escape vehicle power-on stability and performance, canard turnaround and vehicle stabilization, tower jettison, and command module recovery. A malfunction in the real-time display of Mach number versus dynamic pressure caused abort to be initiated earlier than planned, with resultant higher dynamic pressure abort conditions. The abort conditions were more severe than predicted for atmospheric abort during any Saturn IB or Saturn V boost dispersion. Digital simulations using the actual abort conditions showed good agreement with the actual flight performance and stability for both the launch escape vehicle power-on and canard phases of the flight. The launch escape subsystem jettison was clean, with safe separation distances from the command module being achieved. The vehicle was recovered.

Airloads, applicable to Block I and the present Block II configuration, were computed for the forward heat shield, crew compartment, aft heat shield, and total command module for specified flight conditions. These data are required to support structural analysis of the launch escape vehicle during atmospheric aborts. In addition, airload information for the canard surfaces was completed.

The mission sequencer for boilerplate 22 (the high-altitude abort test vehicle) is being redesigned to take advantage of experience gained through minimum-airworthiness tests of the boilerplate 23 sequencer. The new sequencer will use Babcock relay timers because of their higher reliability and their greater resistance to vibration. This is the same type of relay to be used in Block I spacecraft sequencers; thus, advance performance information will be obtained.

Pyrotechnics and Earth Landing Subsystem (ELS)

The ELS development program continued, including four drops at El Centro in a series of tests to determine the safety factor for the Apollo main recovery parachute. Of the four drops made to demonstrate the ability of the main canopy to sustain a maximum load of 35,000 pounds at disreef, only drop 73 met this requirement. On drops 72, 74, and 75 the canopy failed at loads of 25,000 to 27,500 pounds. One drop made in a series of tests to evaluate drogue performance resulted in failure of a main canopy at a disreef load of 28,800 pounds. As a result of these test failures, the subcontractor, Northrop-Ventura, has begun a program to strengthen the main parachute in critical areas. The redesign includes reinforcement of the leading and trailing edges of sails in rings 6, 7, 8, and 9 of the 12-ring main parachute. Fabrication of the new design is under way.

The redundant shaped-charge subsystem for the separation of the command-service module umbilical has undergone a series of tests. The purpose of these tests was to determine the magnitude of the shock load induced into the umbilical fairing and the command module structure by the firing of these shaped charges. Analysis of strain-gauge readings indicates that the shock-load levels are greater than can be safely absorbed. This problem will be eliminated by replacing the present flexible linear-shaped charge method, which separates the umbilical by direct action, with guillotine cutters actuated by much smaller explosive charges. Figure 1 shows the proposed guillotine configuration.

MISSION DESIGN

Design Reference Mission Attitude Sequence and Requirements (SID 64-2046) is being prepared for publication. The document furnishes data supplemental to the design reference mission (for a Saturn V lunar landing mission) issued by the Apollo mission planning task force (AMPTF) in October. The new document will furnish spacecraft attitude rules, requirements, constraints, and other data pertinent to attitude management.

CREW SYSTEMS

A development plan for the crew equipment subsystems is being completed. The document defines the analyses and tests that lead to qualification of crew equipment for lunar orbital rendezvous missions. The biomedical requirement portion of the test plan for the environmental control subsystem breadboard is nearly complete. In addition to the proper inserts into the individual test profiles, 20 appendixes were prepared to cover crew subsystem requirements in the various runs. The communication and bio-instrumentation schematic for monitoring test subjects during the breadboard tests was completed.

The first manned test of the waste management subsystem under zero-g conditions was successfully completed aboard a KC-135 flying laboratory at Wright-Patterson AFB on December 16. With this equipment,

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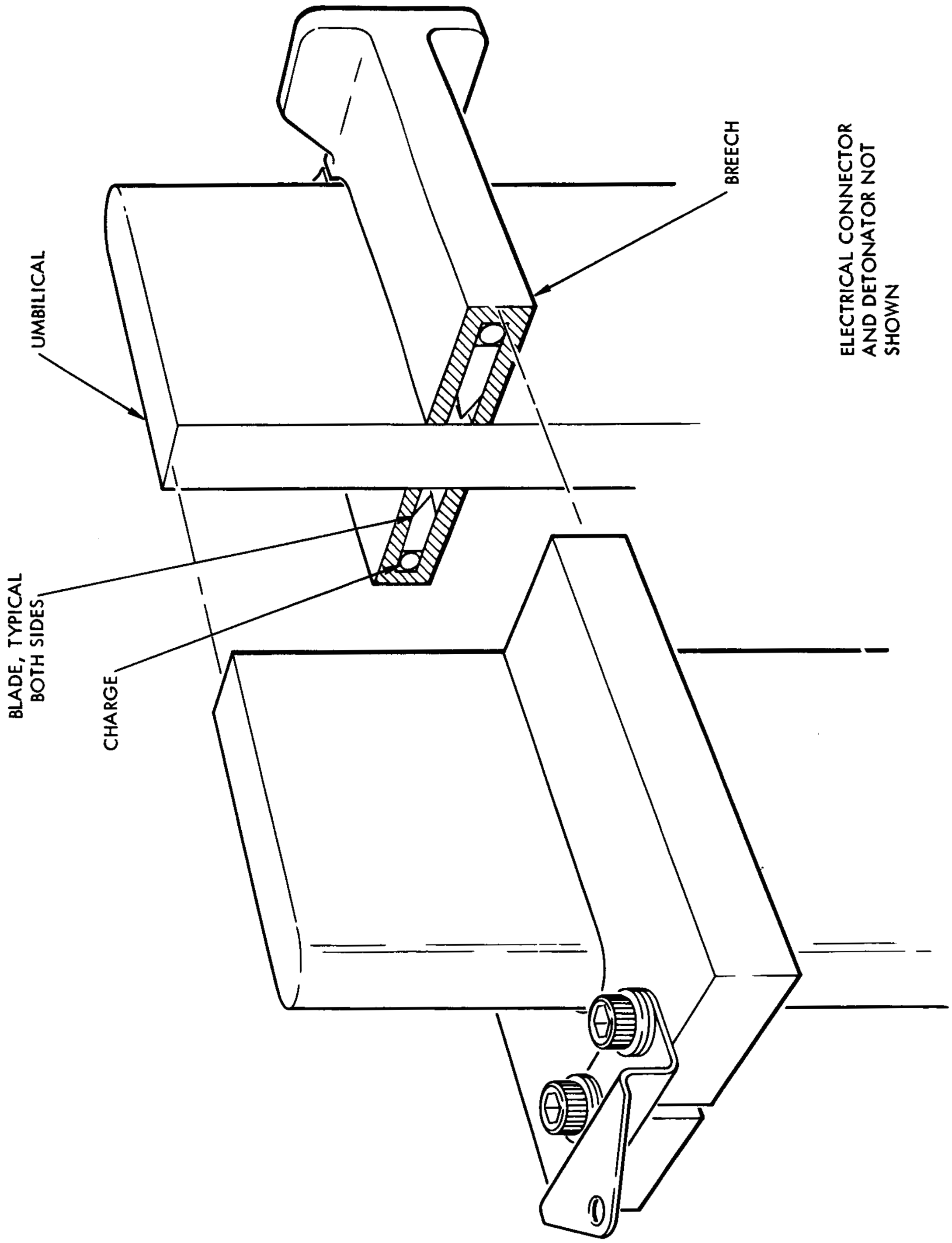

Figure 1. Command-Service Module Umbilical Guillotine Separation Subsystem

complete control of both urine and solid waste matter was achieved without difficulty. During the test, the subject wore Velcro restraint sandals; excellent performance was demonstrated. A complete zero-g waste management subsystem unit, including a flowmeter and a self-contained vacuum source, is being developed for further tests.

STRUCTURAL DYNAMICS

Hydroelastic studies of the command module aft heat shield are in progress. The elastic response of a symmetric aft heat shield to symmetric loading condition for water impact was computed for a range of velocities up to the critical velocity (approximately 15 feet per second). This is the velocity at which a spacecraft heat shield of the configuration simulated by boilerplate 28 in the first water drop would be deformed locally at impact. In addition, computations for an asymmetric heat shield of the new strengthened design and asymmetric loading conditions for water impact were prepared for computer programming. The computations made use of the von Karmann equations for virtual mass with corrections for non-stationary flow given by Shiffman and Spencer in their work on impacting spheres.

The tenth-scale water impact model of the command module was instrumented with strain gauge accelerometers.

Flotation analysis and tests were reviewed at a meeting with NASA-MSC on December 17. As a result of this review, NASA requested additional tenth-scale model tests of the command module with the flotation bag subsystem.

STRUCTURES

Various tests were run during the report period in an effort to resolve the boilerplate 28 aft heat shield problem in preparation for the second drop test of this vehicle scheduled for late January. Boilerplate 28 currently supports spacecraft 009. The effort included beam tests of bond strength of the aft heat shield doubler, local pressure loadings, and a high-energy water drop of quarter-panel specimens of the aft heat shield. Test data and motion pictures are being analyzed.

The 40-inch helium pressure vessels for the service module propulsion subsystem successfully completed shock and leakage tests in the qualification test program. The acceptable helium leakage rate is 8.2×10^{-4} cubic centimeters per second (cc/sec). Three tanks tested showed leakage rates within specification as follows:

3.8×10^{-4} cc/sec
7.2×10^{-4} cc/sec
7.9×10^{-4} cc/sec

Two of these vessels, however, failed prematurely during burst tests after cyclic pressure loading. Failure occurred in the weld area. Design changes are being made to remove an apparent stress concentration at the weld bead.

Qualification testing of the actuators for the astrosextant door mechanism and the inner crew hatch will begin immediately at Kearfott Division, General Precision, Inc.

FLIGHT CONTROL SUBSYSTEM

Guidance and Control

Single-plane operation of thrust vector control will be studied using hardware and an analog computer in a closed loop. The dynamics of the service propulsion subsystem engine will be duplicated in these tests. Checkout of the computer programming is now in process.

The computerized breadboard tests of the entry monitor subsystem (EMS), employing integrated circuit components where feasible, are proceeding with favorable results. The tests are being conducted at Autonetics.

Vibration tests of the engineering model of the EMS plotter assembly are under way. No structural failures have occurred to date.

Plans were completed for mechanization of the runaway RCS jet detector for use on both Block I and Block II vehicles. A panel light will signal the astronauts in the event a single RCS jet continues to fire for more than 10 seconds. Such extended firing represents a failure that would otherwise remain undetected by the astronauts, because an opposing RCS jet would automatically fire in order to correct spacecraft orientation. The detector will prevent potentially serious loss of RCS propellant in the event of such a failure.

Flight Subsystem Analysis

A study of the dynamics of the docking maneuver for the period following capture latch indicates that the lunar excursion module and the command-service module will be unable to complete the hard docking in the event that the attitude references of the control subsystems of the two vehicles are misaligned. Switching the command-service module attitude control subsystem to a rate-damping mode at capture latch would remove the problem.

A minimum electrical impulse width of 18±4 milliseconds was established for all valve-supply voltages in Block I vehicles.

Automated Control

The sequence timer for the spacecraft 009 control programmer was subjected to a centrifugal acceleration force of 25 g's in each direction of three orthogonal axes as part of prequalification testing. No deterioration of performance was noted during or after the tests.

Modular design will be used in the mission control programmer to be fabricated by Autonetics. This plan provides maximum flexibility with optimum growth capability, package density, and part standardization. Package design, layout, and drafting effort are not dependent upon completion of circuit schematics. Completion of detail drawings and initiation of fabrication can proceed even though functional mechanization is in a state of change.

The development plan was completed for the automated control subsystem for both Block I and Block II unmanned missions.

TELECOMMUNICATIONS

Communications

Evaluation of the bid proposals for the high-gain antenna subsystem was completed, and a tentative source has been selected. The high-gain antenna is deployable, and is used for S-band spacecraft-earth communications after an altitude of 8000 nautical miles (NM) has been reached by the Apollo flight vehicle. The procurement specification for the high-gain antenna is being revised, and will be released in February. The supplier will complete the antenna design, furnish an engineering model, complete qualification tests on three units, and deliver one qualified unit. Production units will be ordered on a follow-on contract.

Grumman is investigating two proposed solutions to the thermal environment problem of the rendezvous radar antenna as the result of meetings between S&ID, Grumman, and NASA. The present radar antenna is a fixed-boom antenna located on the service module aft bulkhead near the SPS engine nozzle. One proposed solution consists of the addition of a heat shield on the antenna; the other solution would employ a deployable boom to provide a capability to move the antenna away from the SPS engine nozzle. The GFE Rendezvous Radar and Transponder Performance and Interface Specification (SID 64-690) was published during the report period.

The VHF beacon satisfactorily performed a one-week salt-fog test at Collins Radio, and the Radio Corporation of America successfully demonstrated the infinitely clipped technique for use in VHF speech transmission between the command module and the lunar excursion module. This tech-

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nique conserves primary input power so that greater effective signal strength results. Intelligibility was good; compatibility was demonstrated with both a standard AM receiver and a command-service module VHF receiver.

Acceptance tests were completed for the up-data link equipment and the associated bench maintenance equipment.

A full-scale model of the scimitar antenna with notch was completed. The model can be disassembled for impedance testing; it will be used to determine any changes that may be required in the S-band impedance transformer for the spacecraft 009 surviving antenna because of the presence of the added thermal sensors. The model will also be used to determine the parameters of the S-band impedance transformer for the revised S-band notch.

Instrumentation

The Instrumentation Subsystem Development Test Program Plan was reviewed by S&ID and NASA; mutual agreement was reached.

Of the 61 currently known requirements for instrumentation specification control drawings, 37 have been completed, and 3 are in process.

The thickening of the spacecraft 009 aft heatshield as the result of the first water-impact test of boilerplate 28 requires changes in sensor dimensions. These changes have been determined, and procurement of the redesigned sensor has been initiated.

Design of the modification kit for the instrumentation of the spacecraft 009 service module adapter is 80 percent complete. All necessary procurement has been initiated. The electrical installation mock-up is in process; detail parts are being fabricated.

ENVIRONMENT CONTROL

The spacecraft 008 environment control subsystem (ECS) is being modified as part of the over-all program to make this vehicle functionally the same as spacecraft 012. (Spacecraft 008 is the thermal-vacuum ground test vehicle; spacecraft 012 is the first Apollo manned-flight vehicle.) Coldplate loops and plumbing lines are being modified in spacecraft 008 to reduce pressure drops and increase coolant flow. A warning device to indicate a malfunction of the accumulator units for the ECS water separator will be added. An oxygen flow-rate warning device will also be added to the subsystem. A potable-water assembly will include the capability to meter hot and cold water, and a new food reconstitution probe will be furnished by NASA. None of these changes will affect the remote measurement and remote stimuli subsystems peculiar to this vehicle.

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A Block I single-panel test radiator was completed, and tests were begun to determine radiator performance and flow distribution. Cold cases presently predicted for earth orbit missions were simulated without freezing; heat rejection was 10 percent below prediction. This can be accounted for by the reduced flow in the colder-edge tubes and by laboratory test conditions. Data obtained in the tests indicate that a minor change in the cross section of the outside radiator tubes would recover most of the loss in heat rejections.

The NASA-sponsored ECS radiator study was begun at Ling Temco-Vought to develop the selective-stagnation concept for use in Block II. Initial runs made at high heat loads indicate radiator performance as predicted. During runs made at low heat loads, however, portions of the radiator tubes froze and failed to thaw rapidly enough to meet transient requirements of the spacecraft ECS. Final data evaluaticn is in process.

A transient-case study of the air temperature of the command module cabin was analyzed for ten earth orbits, assuming two astronauts aboard and the service module oriented toward the sun. The average cabin temperature, at the end of ten orbits, was 75.5 F and slowly dropping. Condensation occurred in the vicinity of the cabin floor with minimum average temperature of 46 F in that area.

The master computer program for spacecraft radiation shielding was modified to calculate radiation dosage from secondary neutrons only. Results of computer studies made with this modified program, assuming an aluminum shield thickness of 10 grams per square centimeter and an incident proton beam of 160 million electron volts, correspond within 10 percent to the results obtained in secondary neutron experiments at the Oak Ridge National Laboratory.

Of the 20 temperature-sensitive specimens attached to the boilerplate 23 boost protective cover, only 2 were recovered after flight because the boost cover had been torn off during tumbling. These two samples indicated a maximum surface temperature between 200 F and 300 F.

A thermal analysis was made for the crew-hatch window of the command module for a Block I entry trajectory defined by an undershoot entry corridor (inertial velocity of 28,100 feet per second). Assuming an initial cold-soak temperature, the highest surface temperature to which the quartz window is subjected is 931 F. This is 500 F lower than that predicted for the earlier Block I entry trajectory parameters using identical initial temperature conditions. In addition, the temperature gradients in the quartz window are less severe than for the earlier entry trajectory.

Twenty-three runs were made in the Ames tunnel during the compatibility test of flight test instrumentation and command module aft heat shield. Tunnel calibration runs were made, followed by ablator and flight test sensor runs. Heating rates on the calibration model showed good agreement with predicted values; the prototype flight test sensors and signal conditioner performed favorably.

ELECTRICAL POWER

Three fuel cell powerplants were successfully operated in space vacuum conditions under parallel load for approximately 75 continuous hours. Each of the three power plants has accumulated a total of 180 hours of operation under load in the tests being conducted at S&ID, Downey.

Four of the oxygen surge tanks for the cryogenic gas storage subsystem (CGSS) successfully passed the proof-pressure and design-proof vibration tests as part of the qualification test program.

The redesigned CGSS pressure switch passed the first phase of design verification testing.

The initial draft of the Electrical Power Subsystem (EPS) Development Plan (SID 64-2054) was completed and reviewed by NASA. Changes requested by NASA are being incorporated. The plan presently delineates plans for Block I development, qualification, and ground and flight testing of EPS equipment. The Block II EPS development plan will be incorporated at a later date.

Postflight boilerplate 23 studies show that the EPS performed within specification limits; all pyro devices were properly fired, and bus voltages remained within tolerances throughout the flight. Modification to the spacecraft 012 configuration was initiated on the spacecraft 006 and 008 displays and controls.

Preliminary Block II layouts were completed, showing main wire runs, wire support locations, and wiring from the components in the lower equipment bay to the command module displays and controls and the aft compartment tunnel. The layouts are for use in the Block II mock-up.

The Block II command-service module umbilical wire, coaxial cable, and hardline masses were reexamined; a figure of 15.75 square inches in total cross-sectional area was established.

The Block II electroluminescence samples for displays and controls in the command module were received for evaluation tests in Apollo environments. Test plans include brightness versus voltage, vibration, salt-fog, oxygen-humidity, temperature effects, and life-solar radiation effects.

PROPULSION

Service Propulsion Subsystem (SPS)

The F-2 SPS engine test fixture at the propulsion system development facility (PSDF) was shut down for modification in preparation for the second series of tests. This second series will include SPS engine gimbaling, and will employ a flight-type helium pressure panel to be delivered to PSDF in mid-January.

The spacecraft 001 service module is undergoing checkout at PSDF prior to hot firing. All four probes for the propellant gauging subsystem had been installed prior to shipment of the service module from S&ID in mid-December (Figure 2). SPS engine 010, to be installed in spacecraft 001 at PSDF, was shipped from Aerojet on January 6.

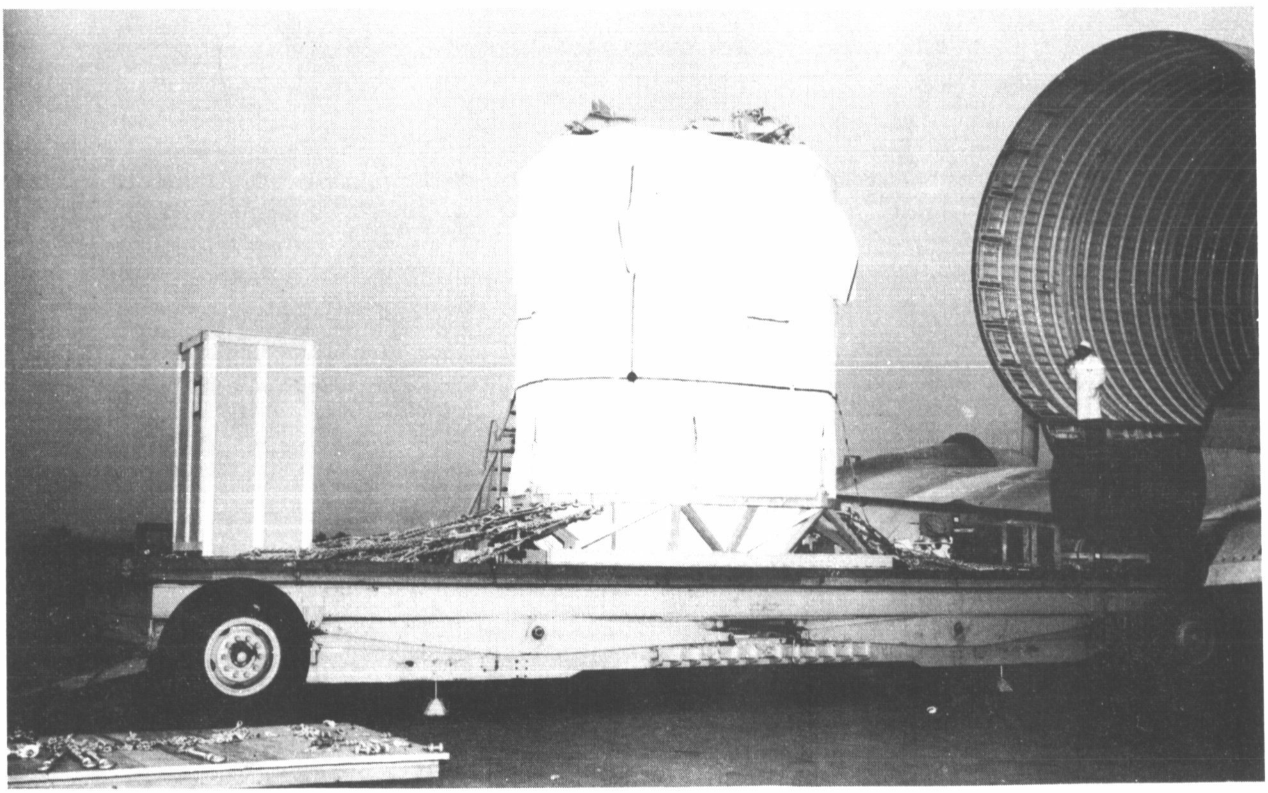

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Figure 2. Loading Spacecraft 001 Service Module Into B-377PG for Shipment to PSDF

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The SPS fuel and oxidizer sump tanks will be modified by the incorporation of an umbrella design retention screen (See Figure 3). The umbrella screens will be used with the present retention reservoirs; the modification will be initially incorporated in spacecraft 012.

The Phase II SPS engine tests at the Arnold Engineering Development Center were begun December 16 under simulated high-altitude conditions with a successful 30-second firing. A total of nine firings were completed; results are being analyzed.

Sixty-six SPS injector firings were completed during this report period in the dynamic stability program at Aerojet. Investigation of a popping phenomenon was begun. This phenomenon is a localized detonation of propellants resulting in pressure perturbations of a self-damping nature, with amplitudes varying from 40 to 200 psi above chamber pressure. Analysis suggests that propellant accumulation on the injector face or baffle surfaces may be the cause. Special care will be required in pattern design near surfaces and corners. Table 1 lists all firings conducted at Aerojet during this report period, including 52 SPS engine firings in the prequalification development program.

Reaction Control Subsystem (RCS)

The first service module RCS engine in the preliminary flight rating test program was rerun through one of the hot-firing sequences as the result of preliminary data analysis. Results of the rerun test are satisfactory. The second preliminary flight rating test engine is undergoing vibration testing. These two engines had previously passed acceptance testing; a third engine, required for acceptance tests, is being manufactured.

The Phase II breadboard of the service module RCS was refurbished in preparation for simulation of the spacecraft 009 duty cycle mission.

Data obtained by Rocketdyne during screening tests of the command module RCS engine injector indicate that the redesigned injector will provide engine performance in excess of specification requirements. The redesign consists of the removal of the chamfer on the oxidizer orifice inlets.

Modification of the Phase IV breadboard of the command module RCS for use as the flightworthiness test stand is in progress,

The explosive valves for the command module RCS of the type to be used in spacecraft 006, 008, and 009 failed the external leakage portion of acceptance testing. A substitute alloy used in the valve body (because of the unavailability of vacuum-melted 304L bar stock) proved to be porous, causing the leakage. The supplier is submitting a recovery plan.

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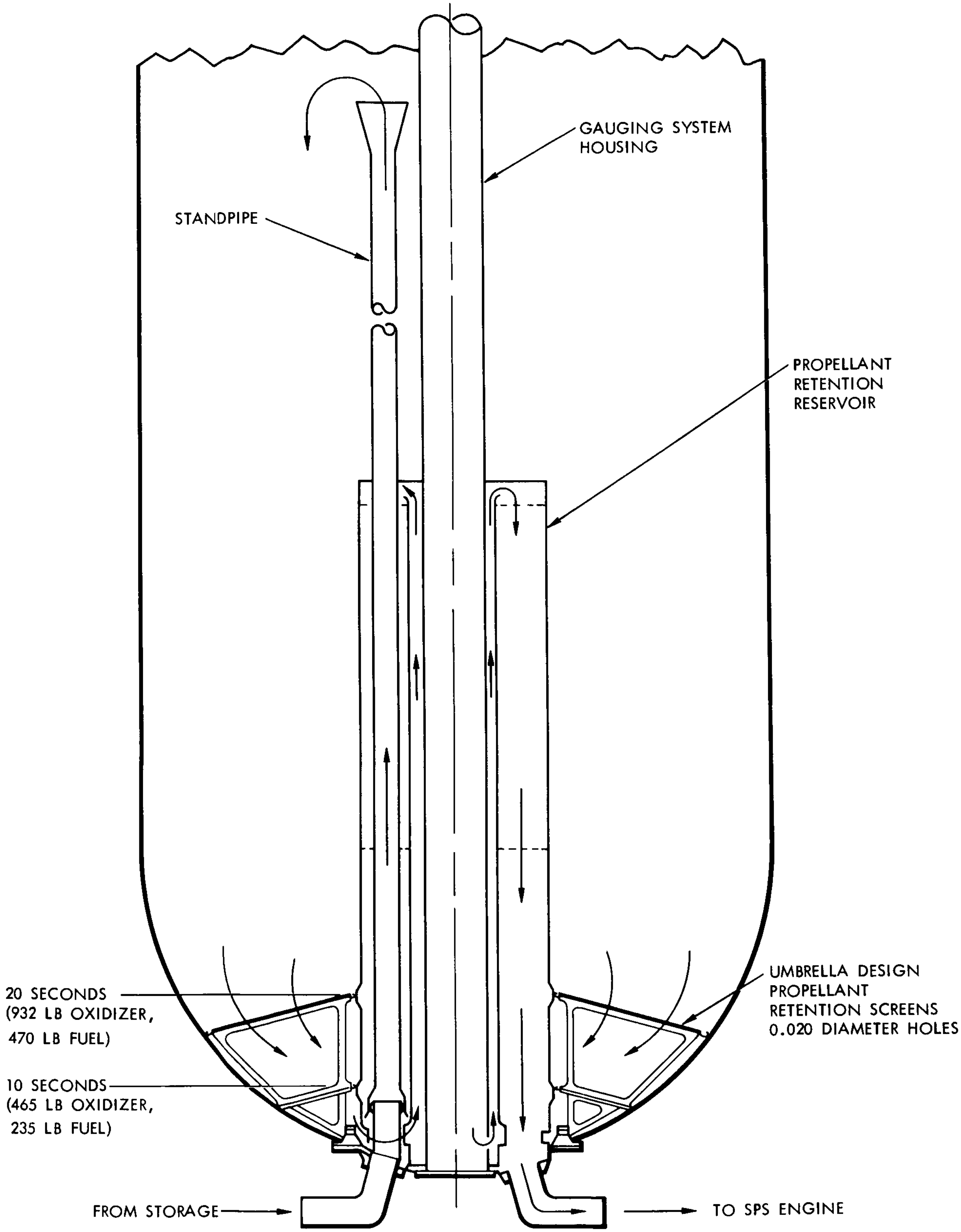

Figure 3. Sump Tank Internal Configuration With Umbrella Retention Screen

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Table 1. Apollo SPS Engine Development at Aerojet

Serial No.	Pattern Type	Type of Evaluation	Ablative Chamber		Steel Chamber		Engine		Test Conditions and Results
			No. of Firings	Time (sec)	No. of Firings	Time (sec)	No. of Firings	Time (sec)	
050	Poul-41-38	Mission	14	188.0					Chamber separated at throat
		Combustion			11	605.0			Water-cooled chamber utilized—popping noted
044	Poul-41-46	Mission	14	753.0					Popping noted—chamber burn-through at the throat
	Poul-41-53	TCA compatibility	3	183.0					Last firing with MMH-CSM shutdown—popping noted
045	Poul-41-49	Combustion stability			2	20.5			Water-cooled chamber utilized
	Poul-41-54	Combustion stability			2	73.9			Water-cooled chamber utilized—last firing shutdown
	Poul-41-54	Combustion stability	2	13.0					MMH used on last firing—popping caused CSM shutdown
046	Poul-41-26	MR Survey			10	50.0			Pulsed during last firing—satisfactory
		Compatibility	1	100.0					Pulsed during test—satisfactory
035	Poul-41-26	C^*			5	26.5			Satisfactory
		Combustion stability	2	751.0					Popping time during last firing
Lngine assembly 007	AFF-54	Balance					2	10.0	Satisfactory
	P_c & MR Survey						41	205.0	Chamber separated at throat

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Table 1. Apollo SPS Engine Development at Aerojet (Cont)

Serial No.	Pattern Type	Type of Evaluation	Ablative Chamber		Steel Chamber		Engine		Test Conditions and Results
			No. of Firings	Time (sec)	No. of Firings	Time (sec)	No. of Firings	Time (sec)	
Engine assembly 017	AFF-35	Balance					3	5.5	Firings 1 & 2 terminated by CSM shutdown
Engine assembly 009	AFF-78	Simulated high altitude					9	291.0	Third firing terminated by CSM

TCA Thrust chamber assembly
MR Mixture ratio: oxidizer to fuel
MMH Monomethylhydrazine
C^* Characteristic exhaust velocity
P_C Pressure chamber
CSM Combustion stability monitor

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The electromagnetic interference (EMI) portion of the design verification testing of the propellant isolation solenoid valves was begun December 29. Test results indicate that a diode will be required in conjunction with the switch leads in order to meet EMI specifications.

A feasibility demonstration of the service module RCS propellant tank was successfully conducted at Wright-Patterson AFB on December 18 during zero-g flight parabolas aboard the KC-135 flying laboratory. A model of the tank was used, equipped with retention screens and a capillary pump between two of the screens. Fluid flow was good, and the pump was able to empty the fluid satisfactorily.

Launch Escape Subsystem (LES)

On January 5, S&ID presented to NASA a report on the completed qualification program for the launch escape and pitch control motors.

Three tower jettison motors were successfully static tested during December in the qualification program. The first qualification motor to undergo accelerated aging was static-fired on January 11. Aging began October 16, with the motor maintained at 160 F for 75 days. Preliminary results of the firing indicate that all test objectives were met. Vibration tests of the jettison motor began January 13.

The three boilerplate 23 LES motors performed successfully, and ballistic parameters agreed with predicted values. The nozzle of the jettison motor was offset to produce a thrust vector angle of 3.8 degrees instead of the 2.5 degrees for earlier flights. The larger angle was required by the addition of the boost protective cover.

Propulsion Analysis

An analysis was completed of the thermal control requirements of the command module RCS for spacecraft 009, 011, 012, 014, and 015. The results indicate that engine valve heaters are not required for spacecraft 009 and 011 because of short flight time, but are required for spacecraft 012, 014, and 015. The solenoid valve coils of the command module RCS could be used as heaters, thereby eliminating the need for separate heaters. Two switches located in the command module cabin would be used to energize simultaneously all the RCS engine valves of either of the two redundant RCS subsystems. Thermocouples on the RCS engine valves would be connected through a rotary switch in the cabin to a single temperature gauge display. Heating would be done prior to entry, and thus would not interfere with the primary valve function.

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GROUND SUPPORT EQUIPMENT (GSE)

The spacecraft instrumentation test equipment (SITE) for Building 290 was satisfactorily demonstrated to NASA, and was accepted on an interim basis, pending incorporation of seven required changes. The second SITE unit was completed by Autonetics. Integrated testing is in progress.

The first propulsion subsystem fluid checkout unit (See Figure 4) was fabricated and shipped to PSDF for use in checkout of the spacecraft 001 service module. The unit will perform functional and leak testing of the installed RCS in both the service and the command modules, and the SPS in the service module. These tests are accomplished by supplying accurately controlled helium pressures to the spacecraft and by monitoring pressure and flow rates. The pressures to be monitored range from 0.5 to 4500 psig, at flow rates ranging from 8 to 1200 cfm. The unit is designed to receive gaseous helium supply pressures of 5000 to 6000 psig and gaseous nitrogen at 500 to 3000 psig. The nitrogen will be furnished to the spacecraft at a flow rate of 150 cfm for purging of the spacecraft propulsion subsystems. The unit includes a volumetric leak detector capable of measuring leaks as small as 1×10^{-3} cubic centimeters per second.

Functional testing of the polarity checker unit (See Figure 5) was completed in Building 290.

A study was made of the over-all hardware requirements for spacecraft acceptance checkout equipment (ACE-SC) for all Apollo spacecraft at all sites. The study considered maximum utilization of ACE-SC hardware. Results of the study were presented to NASA, and agreement was reached on ACE-SC requirements.

The house spacecraft area in Building 290, S&ID, Downey, will have full ACE-SC capability; the test preparation area of Building 290 will have minimum ACE-SC hardware, and will make maximum use of the manual capability of GSE service equipment. At the Florida facility, the operations and control building will have minimum ACE-SC equipment with maximum utilization of GSE equipment; pads 34 and 39 will have full ACE-SC capability.

Source selection for the follow-on procurement of ACE-SC carry-on and external (digital test command subsystem) equipment was completed, and source recommendation was made to NASA on January 5.

All GSE electrical equipment was delivered to PSDF to support the hot firing of the SPS engine and the subsequent electrical subsystem tests. The GSE electrical models delivered included the SPS valve driver and monitor, the SPS checkout and control unit (described in the first part of the GSE section), the electrical load bank, and the ground power distribution unit.

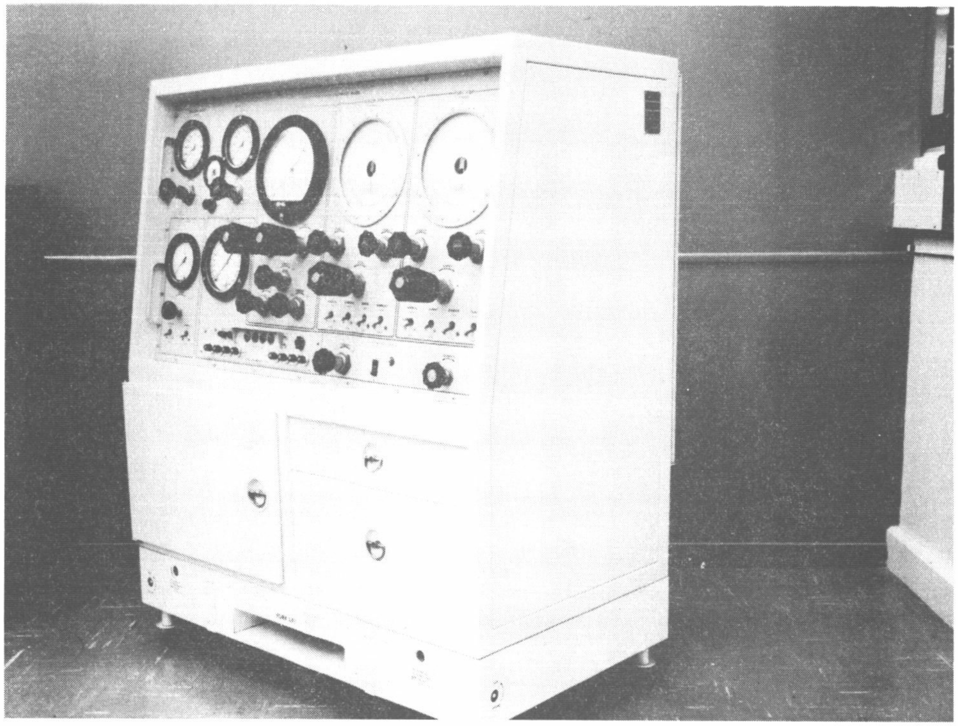

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Figure 4. Propulsion Subsystem Fluid-Checkout Unit

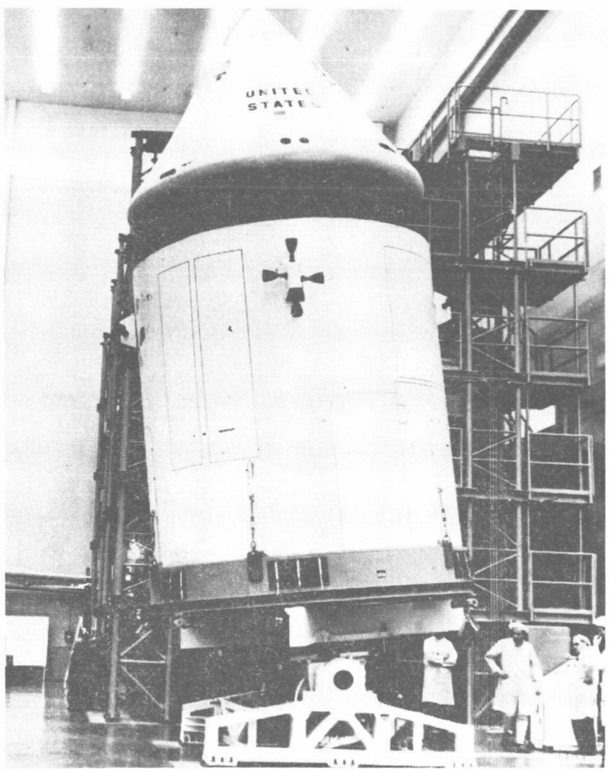

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Figure 5. Polarity Checker Unit

The seven electrical GSE models required to support boilerplate 22 were completed. Five of these units were modified from existing models to meet schedules. The initiator stimuli unit and the pyrotechnic initiator substitute unit were the only new units furnished.

SIMULATION AND TRAINERS

The combined-system checkout portion of the spacecraft 009 mission evaluation study was completed January 5, using a hybrid computer complex. Digital and analog computers were used with a simulated ground control console and associated peripheral hardware. Data are being evaluated.

The IBM 7040 digital programming effort is 80 percent complete.

Installation of the real-time simulation subsystem was completed January 4 at S&ID, Downey, as part of the Apollo simulation equipment; checkout by the supplier was completed, and acceptance testing is in progress.

The interface console for the docking simulation studies at Langley Field was completed January 5. The console will be shipped to Langley upon receipt of NASA instructions.

The Apollo Training Equipment Specification (SID 64-1807) was completed. This document is the end-item requirement specification covering the two Apollo mission simulators (AMS) and the five system trainers. Revision B of the Trainer Mission Simulator Procurement Specification for the AMS and an initial design reference mission for the AMS were also completed. A meeting was held with Link, the AMS subcontractor, regarding use of GFE booster tapes for the AMS, supplemental AMS equipment to update to spacecraft 012, and implementation of the Block II AMS program. A second meeting on January 6 and 7 to discuss the incorporation of the GFE tapes was attended by NASA, S&ID, and Link.

A design review meeting of the AMS sextant and telescope was held at Librascope on January 12 and 13; representatives from NASA, S&ID, and Link attended. The Librascope design approach is being analyzed.

The last two of the five system trainers, the sequential flow and propulsion subsystem, were accepted by NASA on January 14 and were shipped to NASA-MSC on January 15.

A preliminary test and acceptance plan was received from Astrodata covering the computer complex of the cancelled Apollo part task trainer (APTT). The computer complex will be diverted to other use. Revisions in the plan requested by S&ID are being incorporated. Delivery of the computer complex has been rescheduled to late March.

Procurement of the visual displays for use in the mission evaluation studies, using evaluators 1 and 2, was reinstated on a reduced basis; procurement specifications are being released. Supplier negotiations for the earth model were completed, and fabrication is under way.

Structural modification of the evaluator 1 command module to the spacecraft 012 configuration was completed. Display and control panels are being fabricated for installation in the evaluator.

VEHICLE TESTING

Ground Test Vehicles

The modification of boilerplate 14 to equal the configuration of spacecraft 009 as closely as possible is under way. Breadboard sequencers are available, and required ACE-SC and GSE modifications are under way.

The aft bulkhead for boilerplate 28 was completed and is being incorporated. Rework of the spacecraft 007 aft heat shield for use on boilerplate 28 is in progress.

Fabrication of the boilerplate 29 command module is on schedule. All outer-structure support members were installed; side heat shield panels were fitted and trimmed. The additional requirements for postlanding electrical harness, connectors, and wiring will be incorporated. This vehicle will be used by NASA to demonstrate dynamic flotation characteristics and to test the uprighting bag subsystem in appropriate sea environments.

Spacecraft 006 is being reconfigured to the spacecraft 012 instead of spacecraft 011. Updating of spacecraft 012 will include the latest configurations of guidance and control for Block I flight vehicles by the substitution of series 100 for series 0 guidance and navigation equipment, and Block K for Block H stabilization and control subsystem equipment. The mission control programmer will be added with changes in the associated main displays and controls.

Flight Test Vehicles

Boilerplate 22 is being assembled into a stacked configuration, after which system checkout will begin. Joint consideration was given by S&ID, NASA, and General Dynamics, Convair, to the proposed steel bulkhead to be installed at the interface between Little Joe II and the service module. The bulkhead is one inch thick and weighs 7500 pounds. It would serve

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as a blast barrier, and would also provide the ballast needed to shape the test vehicle trajectory to yield the desired test point. Direction to implement this change has not yet been received by S&ID.

RELIABILITY

The failure, during the flight of boilerplate 15, of the calorimeter installed under the nozzle of the service module RCS was attributed to high-frequency, high-decibel acoustic levels in that area during transonic boost. To verify this analysis, laboratory tests were conducted simulating these conditions. Two calorimeters failed during these laboratory tests. On one calorimeter, a wire broke at the diaphragm; on the other, the diaphragm bond separated along approximately 180 degrees of its periphery. Corrective measures will be taken on future instrumentation installations in test flights to accommodate the more severe acoustic environment encountered in the nozzle area.

S&ID and Rocketdyne reviewed the acceptance test criteria for the command module RCS engines in order to assure compliance with specifications and yet provide realistic schedule support. The acceptance test criteria for the model SE 8-9 engine to be used on spacecraft 009, and possibly spacecraft 011, was agreed on as follows: (1) the best fit of the engine performance data plot (total impulse versus firing time) must be above the mutually agreed-upon minimum curve, (2) the standard deviation of the 15-pulse acceptance test data points must not exceed ±10 seconds. In order to release the required test specification, conditional approval was granted for the model SE 8-5 engine (qualification configuration). This conditional approval is subject to review in February based on the evaluation of pulse-calibration data and an error analysis.

A study was made of the Eagle-Picher entry and postlanding battery that failed to meet the insulation resistance requirements following the humidity portion of the qualification program. Investigation disclosed that an error in the assembly of the battery seal had resulted in the leakage. No additional qualification tests will be required as a result of this failure. Assembly techniques have been corrected and closer inspection methods have been adopted to eliminate the problem.

Corrective measures were recommended to eliminate future fan failures in the GSE toxic vapor disposal units. The recommendations consist of the following: high-strength bolts of larger diameter corrosion-resistant steel, the inclusion of automatic shutoff valves in the toxic-vapor lines, and fan blades tested to 1.5 times actual dynamic loads and dynamically balanced to 1.5 times actual maximum speed.

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INTEGRATION

The quality verification vibration test (QVVT) program is being implemented. The QVVT test fixtures for both the command and service modules were designed, and fabrication is under way. Procurement specifications for QVVT control instrumentation and recording equipment were completed; procurement has been initiated. Many of the simulated subsystems designed for the spacecraft 007 command module will be diverted to the spacecraft 006 command module for temporary use to obtain a representative flight configuration. Actual propellant tanks (liquid ballasted) and dummy cryogenic tanks will be used in the spacecraft 006 service module. The spacecraft 006 QVVT validation period was extended from two weeks to three weeks (March 29 to April 16). Low-level vibration tests will be used to check out QVVT equipment and determine test parameters for flight vehicles.

The postflight inspection of various components of boilerplate 23 showed nominal erosion of the LES motor throats with no evidence of hot spots. The canard thruster still retained pressure. All explosive bolts showed clean, sharp separation. Of the three onboard motion picture cameras, the tower and command module cameras produced a great deal of usable film; the service module camera produced no usable film. The earth-landing subsystem performed satisfactorily, with no evidence of contact with the boost protective cover. The parachutes sustained only minor ground damage. The command module aft heat shield and cabin floor were apparently damaged both during separation from the boost vehicle and earth landing.

The effects on Block I control weights of the 2500-pound increase in the lunar excursion module weight (from 29,500 to 32,000 pounds) were studied. Preliminary results show that this change would require a 25- to 50-pound increase in the weight of the docking probe drogue structure and a 50-to-100-pound increase in the weight of the spacecraft-lunar excursion module adapter.

During this report period, the following interface control documents (ICD) were completed and transmitted to the designated associate contractors:

ICD Number	Title	Associate Contractor
MH01-01226-216	Central Timing Equipment Subsystem Pulse (Block I, Series 100)	MIT
MH01-01280-216	Vehicle Separation Signals to Apollo Guidance Computer (Block I, Series 100)	MIT
MH01-05118-424	SLA/LEM[1] Interface Design Loads and Criteria	Grumman
MH01-15010-116	Drain Line-Urinal-Pressure Garment Assembly Interface, Block I	NASA
MH01-06119-116	Connector-Drain Line-Urinal Pressure Garment Assembly Interface, Block II	NASA

BLOCK II HIGHLIGHTS

Meetings were held during the week of January 4 between NASA and S&ID to complete the Block II preliminary design requirements phase of the Block II Program. Completion of this phase was a necessary step leading to definition of system interface.

The first part of a Block II critical design review was held by NASA and S&ID on January 14 and 15 to review the Block II lower equipment bay and forward compartment design. The agenda included mock-up specifications and the fidelity of the mock-ups to be built in the Block II Program. A presentation was also made on implementation of preliminary design reviews and critical design reviews in regard to the Block II schedule.

[1]Spacecraft-lunar excursion module adapter/lunar excursion module

OPERATIONS

DOWNEY

Boilerplate 14

Work continues on modification of boilerplate 14 and associated equipment to the required configuration for sequencer testing. Installation of the battery cold plates was completed, and the environmental control subsystem was flushed. The inverters were removed, and the inverter cold plates were changed. A new water-glycol pump was installed and checked out.

Checkout of the launch vehicle substitute unit was completed satisfactorily. The sequencer harness installation was accomplished, and the continuity checks were completed. Seventeen display panels were reworked to the spacecraft 009 configuration.

Spacecraft 001

Spacecraft 001 was transported to Long Beach for air shipment to WSMR on December 17. The service module arrived at Holloman Air Force Base on December 18.

Testing of spacecraft 001 reaction control subsystem (RCS) engine quads was initiated. RCS engine quads B and D satisfactorily passed preliminary leak tests.

WHITE SANDS MISSILE RANGE (WSMR)

Propulsion System Development Facility (PSDF), Test Fixture F-2

Updating of test fixture F-2 and facility modifications were started after completion of test series 1. The interim fire control console and associated wiring were removed from the blockhouse. The F-2 test fixture bird cage modification, allowing installation of service propulsion engines with gimballing capability, was completed; the complete installation and alignment were accepted on January 12.

Installation of the test fixture flame shield modification was completed, and all rework with the thrust chamber replacement on engine 0006 was accomplished.

Spacecraft 001

Transfer of spacecraft 001 to the PSDF was delayed until December 19, because a severe sleet and snow storm closed the highways. The receiving inspection was completed. The spacecraft electrical continuity checks were completed satisfactorily. The fluid distribution subsystem quick disconnects mated properly with the spacecraft service propulsion subsystem (SPS). Modification to the adapter ring was completed to provide clearance for the bolts protruding from spacecraft 001.

The service propulsion engine alignment set was fit-checked to engine 0006. A fit-check of the 12 vehicle GSE interface umbilicals was accomplished. Service propulsion engine 0010 was installed in the spacecraft.

Boilerplate 23 (Mission Abort)

The delaminated panels of the boilerplate 23 heat shield were removed for inspection. The aft heat shield pressure transducers were removed for calibration. All parachute attach points and associated hardware were removed for X-ray inspection. The parachutes were packed for shipment. The mission sequencers were removed and returned to Downey for rework to the spacecraft 001 configuration.

FLORIDA FACILITY

Boilerplate 16

Buildup of the launch escape subsystem (LES) for boilerplate 16 was accomplished. The six explosive bolts for support of boilerplate 16 operations were shipped to Florida from WSMR. Installation of the explosive bolt bodies and tower feet was completed on December 30. The LES motor assembly was painted on January 4, and LES weight and balance determination was completed on January 7.

The boilerplate 16 command module was mated to the service module on January 13. Modification of the LES handling sling was completed on January 14, and sling proofloading was accomplished on January 15.

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FACILITIES

DOWNEY

Automatic Checkout Equipment (ACE-SC), Building 290

Facility modification work required to implement ACE-SC station three was completed. Equipment installation is complete, and the rebalancing of the air conditioning system has begun. General Electric is scheduled to start acceptance testing of the station on January 20.

Quality Verification Vibration Testing, Building 290

Fabrication of the basic quality verification vibration testing (QVVT) system by Ling Electronics is in progress. The procurement specification for the monitoring and control system is being prepared.

Building 290 Addition

The builder has removed the concrete tilt-up panels from the south wall of Building 290 and has installed temporary weather curtains. The south hangar door has been removed and is being reworked. The project is approximately 22 percent complete.

Display and Design Engineering Inspection Area, Building 1

Construction of the display and design engineering inspection area is approximately 70 percent complete.

Compton

The contract for the occupancy construction in Building 343 was awarded during the report period, and construction started January 6, 1965.

Block II Tooling Analysis

An analysis is being conducted to determine the potential impact on facilities caused by Apollo Block II tooling changes and additions. Present effort is being directed toward determination of additional area requirements during the transitional stage between Block I and Block II production.

APPENDIX

S&ID SCHEDULE OF APOLLO MEETINGS AND TRIPS

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S&ID Schedule of Apollo Meetings and Trips
December 16, 1964, to January 15, 1965

Subject	Location	Date	S&ID Representatives	Organization
Operational readiness conference	Houston, Texas	Dec 17 to 18	Howard, Jones	S&ID, NASA
Qualification test program discussion	Elkton, Maryland	Dec 18 to 23	Yee	S&ID, Thiokol
Acceptance test on S-band power amplifier, witnessing	Cedar Rapids, Iowa	Dec 20 to 22	Hall	S&ID, Collins
Docking subsystem test equipment meetings	Houston, Texas	Dec 20 to 23	Underwood	S&ID, NASA
Engineering coordination meeting	White Sands, New Mexico	Dec 20 to 23	Morris	S&ID, NASA
Process specification review	White Sands, New Mexico	Dec 27 to 30	Kischer	S&ID, NASA
Delivery schedule discussions	Scottsdale, Arizona	Dec 28 to 30	Skelton	S&ID, Motorola
Management review meeting	Minneapolis, Minnesota	Dec 28 to 29	Sherman	S&ID, Honeywell
Support equipment program, discussions	Minneapolis, Minnesota	Dec 28 to Jan 18	Gibson	S&ID, Honeywell
Engineering coordination meeting	Sacramento, California	Dec 28 to 31	Sheffer	S&ID, Aerojet
Development test planning meeting	Houston, Texas	Dec 29 to 30	Osbon	S&ID, NASA
Lunar reference trajectory subpanel meeting	Houston, Texas	Jan 4 to 5	Hengeveld	S&ID, NASA
ICD working group meeting	Houston, Texas	Jan 4 to 5	Lucas	S&ID, NASA
Foundation requirements meeting	Cocoa Beach, Florida	Jan 4 to 6	Corliss	S&ID, NASA
Digital test command source selection meeting	Houston, Texas	Jan 4 to 6	Edwards	S&ID, NASA
Reliability briefing	Houston, Texas	Jan 4 to 5	Feltz	S&ID, NASA
Engineering coordination meeting	Sacramento, California	Jan 4 to 6	Colston	S&ID, Aerojet
Engineering activities direction	Las Cruces, New Mexico	Jan 4 to 8	Eslinger	S&ID, NASA
Coordination of support operations	Cape Kennedy, Florida	Jan 4 to 8	Shaughnessy	S&ID, NASA

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S&ID Schedule of Apollo Meetings and Trips
December 16, 1964, to January 15, 1965 (Cont)

Subject	Location	Date	S&ID Representatives	Organization
Change notices, negotiations	Rolling Meadows, Illinois	Jan 4 to 8	Schiavi, Cason, Simonsen, Yui, Fatur	S&ID, General Time
Project engineering coordination	Sacramento, California	Jan 4 to 9	Mower	S&ID, Aerojet
Support operations, coordination	Las Cruces, New Mexico	Jan 4 to 11	Wolfe	S&ID, NASA
Design verification tests, surveillance	Buffalo, New York	Jan 4 to 15	Martin	S&ID, Bell
Facility/GSE site activation meeting	Las Cruces, New Mexico	Jan 5	Sommers	S&ID, NASA
Design reference mission review	Bethpage, L.I., New York	Jan 5 to 7	Lopez	S&ID, Grumman
Guidance and navigation working group meeting	Cambridge, Massachusetts	Jan 5 to 7	Gresham, Hitz	S&ID, MIT
Design review meeting	Binghamton, New York	Jan 5 to 8	Marshall, Frimtzis, Franke	S&ID, General Precision
Block I vehicle task force meeting	Houston, Texas	Jan 5 to 8	Orville	S&ID, NASA
Fluid Distribution subsystem review meeting	Houston, Texas	Jan 5 to 8	Taylor	S&ID, NASA
Qualification and acceptance test meeting	E. Hartford, Connecticut	Jan 5 to 8	Nash, Garnett	S&ID, Pratt & Whitney
Engineering coordination meeting	Cedar Rapids, Iowa	Jan 5 to 8	Percy	S&ID, Collins
GSE requirements, review	Houston, Texas	Jan 5 to 8	Foust, Boose, Howard	S&ID, NASA
Guidance and navigation subsystem, meeting	Cambridge, Massachusetts	Jan 5 to 9	Beck, Monzon, Walkover, McDonald, Copeland	S&ID, MIT
GSE requirements, review	Houston, Texas	Jan 5 to 8	Howard, Moulton	S&ID, NASA
Engineering coordination meeting	Binghamton, New York	Jan 5 to 8	Frimtzis, Rogers, Kitakis	S&ID, General Precision
Design review meeting	Binghamton, New York	Jan 5 to 14	Hatchell, Marshall, Franke, Frimtzis, Kitakis, Rogers, Brodersen, Petak	S&ID, General Precision
Flight plan review	Cambridge, Massachusetts	Jan 6	Hogan	S&ID, MIT

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S&ID Schedule of Apollo Meetings and Trips
December 16, 1964, to January 15, 1965 (Cont)

Subject	Location	Date	S&ID Representatives	Organization
Engineering evaluation meeting	Sacramento, California	Jan 6 to 8	Palmer	S&ID, Aerojet
Procurement specification review meeting	San Carlos, California	Jan 6 to 8	Langager, Johannes, Lazarus	S&ID, Pelmec
Engineering coordination meeting	Las Cruces, New Mexico	Jan 6 to 15	Roberts	S&ID, NASA
Connector and wiring coordination meeting	Houston, Texas	Jan 7 to 8	Johnson, Drouillard	S&ID, NASA
Injector program evaluation	Sacramento, California	Jan 7 to 9	Cadwell	S&ID, Aerojet
Boilerplate 23 report review board	Houston, Texas	Jan 10 to 12	Cole, Helms	S&ID, NASA
Monthly prelaunch checkout coordination meeting	Cambridge, Massachusetts	Jan 8 to 15	Harkins, Gilson, Corvese, Morris	S&ID, MIT
GSE/vehicle integration meeting	Las Cruces, New Mexico	Jan 8 to 22	Martz, Anderson	S&ID, NASA
Manpower schedule problems, coordination	Cape Kennedy, Florida	Jan 10 to 14	Pearce	S&ID, NASA
Test data sheets, review	Houston, Texas	Jan 10 to 15	Sheeren, Hardenbrook, Whipple, Milliken, Siwolop, Courtis, Lindsay, Calvert, DeJoy, Templeton, Shelly, Smith, Grosch, Nielson, Motoike, Schofield, Livingstone, Dale, Randall, Pearce, Hartley, Gresham, Garcia, Dunham, Milham, Gallanes, Hunter, Moore, Meyers, Brown, Janus, Hyde	S&ID, NASA
Spacecraft 001 technical support	Las Cruces, New Mexico	Jan 10 to 16	McDonald	S&ID, NASA
Management review meeting	Buffalo, New York	Jan 10 to 13	Mihelich, Gibb	S&ID, NASA
Plan of action meeting	Bethpage, L. I., New York	Jan 10 to 14	Paden, Romey, Maccarone	S&ID. Grumman
Qualification and acceptance procedure meeting	E. Hartford, Connecticut	Jan 10	Nash	S&ID, Pratt & Whitney

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S&ID Schedule of Apollo Meetings and Trips
December 16, 1964, to January 15, 1965 (Cont)

Subject	Location	Date	S&ID Representatives	Organization
Associate contractor support, integration and coordination	Bethpage, L.I., New York	Jan 10 to 15	Gilio	S&ID, Grumman
Spacecraft 008 coordination meeting	Houston, Texas	Jan 10 to 15	Bluestone	S&ID, NASA
Engineering coordination meeting	Tullahoma, Tennessee	Jan 10 to 22	Sheffer	S&ID, NASA
Equipment design negotiation requirements	Cocoa Beach, Florida	Jan 11 to 13	Rovelsky	S&ID, NASA
Centrifuge design configuration meeting	Houston, Texas	Jan 11 to 13	Staniec	S&ID, NASA
Weight coordination meeting	Minneapolis, Minnesota	Jan 11 to 13	Frost, Gasparre	S&ID, Honeywell
Boilerplate 23 coordination meeting	Las Cruces, New Mexico	Jan 11 to 13	Lish	S&ID, NASA
High-gain antenna proposal evaluation	Houston, Texas	Jan 11 to 13	Treman, McCabe, Ross, Ilinski, Wickert	S&ID, NASA
Block II SCS program plan discussion	Minneapolis, Minnesota	Jan 11 to 13	Edziak, Pumphrey, Lewotsky, Stiles	S&ID, Honeywell
EDS design subpanel meeting	Houston, Texas	Jan 11 to 13	Pringle	S&ID, NASA
Tooling coordination meeting	Middletown, Ohio	Jan 11 to 13	Best, Sinai	S&ID, Aeronca
Field analysis and negotiation, meeting	Middletown, Ohio	Jan 11 to 14	Stover, Hanifin, Confer, Hiers, Smith	S&ID, Aeronca
Centrifuge program meeting	Houston, Texas	Jan 11 to 14	Green	S&ID, NASA
Flight mechanics, dynamics, guidance and control panel meeting	Huntsville, Alabama	Jan 11 to 14	Lucas	S&ID, NASA
Design review meeting	Rockville, Maryland	Jan 11 to 15	Petak, Brodersen	S&ID, Librascope
Electrical power subsystems & sequential subsystems briefing	Houston, Texas	Jan 11 to 15	Baggs	S&ID, NASA
Command and service module ground operation requirement plan review	Houston, Texas	Jan 11 to 16	Gallanes	S&ID, NASA

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S&ID Schedule of Apollo Meetings and Trips
December 16, 1964, to January 15, 1965 (Cont)

Subject	Location	Date	S&ID Representatives	Organization
Welding practices, procedures, review	Rolling Meadows, Illinois	Jan 12 to 13	Covington, Boyd	S&ID, General Time
Block II antenna briefing	Houston, Texas	Jan 12 to 13	Bologna, McQuerry	S&ID, NASA
Spares provisioning procedure, discussion	Houston, Texas	Jan 12 to 14	Ogren	S&ID, NASA
Electrical subsystems integration panel meeting	Houston, Texas	Jan 12 to 14	Ryland, Kenny	S&ID, NASA
Ground development test working group meeting	Houston, Texas	Jan 12 to 14	Beckner	S&ID, NASA
Spacecraft 008 test and checkout requirements, review	Houston, Texas	Jan 12 to 15	Howard	S&ID, NASA
Site activation review	Cocoa Beach, Florida	Jan 13 to 15	Feltz	S&ID, NASA
Margin determination for ordnance subsystems, meeting	Houston, Texas	Jan 13 to 17	Sweet	S&ID, NASA
Off-site testing and site activation programs, meeting	Houston, Texas	Jan 13 to 19	Webb	S&ID, NASA
Technical progress monitoring and evaluation	Sacramento, California	Jan 13 to 23	Mower	S&ID, Aerojet

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